PATENT ABSTRACTS OF JAPAN

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(71)Applicant : **CANON INC**

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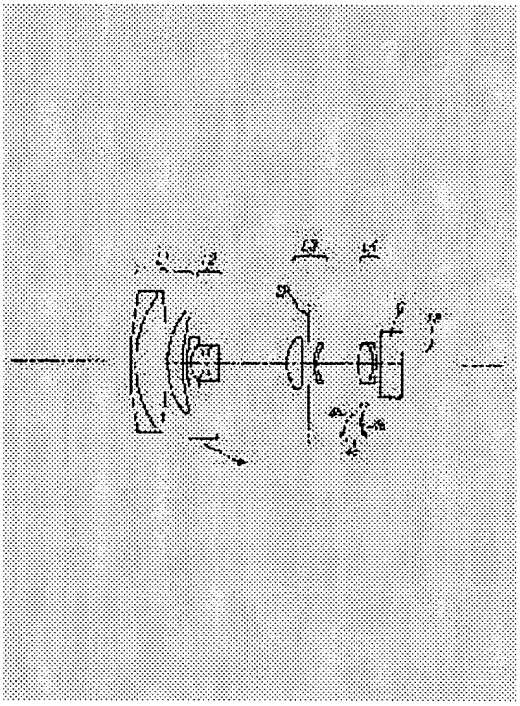
(54) **ZOOM LENS**

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain a rear focusing type zoom lens which is constituted of four lens groups and in which an entire lens system is miniaturized.

SOLUTION: This zoom lens is provided with the four lens groups of a first group L1 having positive refracting power which is fixed in the middle of variable power, a second group L2 having negative refracting power, a third group L3 having positive refracting power, and a fourth group L4 having positive refracting power in order from an object side; the variable power from a wide angle end to a telephoto end is performed by moving the second group L2 on an image surface side, image surface fluctuation in accordance with the variable power is corrected by moving the fourth group L4, and also focusing is performed by moving the fourth group L4. Assuming that a distance from a first lens surface on the object side to a paraxial image surface is defined as TD when an optical member without the refracting power on the image surface side is removed, and the focal distance of an entire system on the telephoto end is defined as fT, the condition of $0.8 \leq TD/fT \leq 1.05$ is satisfied.



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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] The photography field angle of a wide angle edge is related with a small zoom lens with the short lens overall length of a high variable power ratio by the diameter ratio of macrostomia of 60 degrees or more by the variable power ratio 10 and the about 1.8 to 2.6 f number by which especially this invention is used for a photographic camera, a video camera, the camera for broadcast, etc. about a zoom lens.
[0002]
[Description of the Prior Art] What adopted the so-called rear focus type which is made to move lens groups other than the 1st group by the side of a body in zoom lenses, such as a photographic camera and a video camera, conventionally, and performs a focus is proposed [that it is various and].
[0003] Compared with the zoom lens which the zoom lens of a rear focus type makes move the 1st group generally, and performs a focus, the effective diameter of the 1st group becomes small, the miniaturization of the whole lens system becomes easy, and since contiguity photography, especially pole contiguity photography become easy and are carrying out by moving a further comparatively small lightweight lens group, the driving force of a lens group is small and ends, and there are the features, like quick focusing is made.
[0004] The image surface fluctuation accompanying [have four lens groups of the 4th group of the 3rd group of the 2nd group of the 1st group of refractive power more nearly forward than a body side to order with JP,62-247316,A, JP,62-24213,A, and JP,5-60974,A and negative refractive power and forward refractive power and forward refractive power, move the 2nd group, perform variable power, move the 4th group, and] variable power and a focus are performed.
[0005] Among these, by JP,5-60974,A, the 3rd group is constituted from a positive lens and a negative lens of the shape of a meniscus which turned the convex to the body side, and shortening of a lens overall length is attained.
[0006]
[Problem(s) to be Solved by the Invention] If a rear focus method is generally adopted in a zoom lens, the whole lens system will be miniaturized and a quick focus will become possible. However, on the other hand, the aberration fluctuation in the case of a focus becomes large, and the trouble that it becomes very difficult to obtain high optical-character ability arises, attaining the miniaturization of the whole lens system covering the object distance at large [from an infinite distance body to a short-distance body]. With the zoom lens of the high variable power especially in the diameter ratio of macrostomia, the trouble that it becomes very difficult to obtain high optical-character ability again covering the object distance at large over all variable power range arises.
[0007] For example, if the refractive power of the 3rd group tends to be strengthened in the zoom lens which consists of four lens groups mentioned above and it is going to shorten the lens overall length after the 3rd group There was a trouble that the variable power of the 4th group or the movement magnitude at the time of focusing becomes large too much, and the 3rd group and the 4th group will interfere in mechanism, or had to stop having to extend air spacing of the 3rd group and the 4th group, and a lens overall length will become long conversely to the contiguity body of a zoom staging area.
[0008] Moreover, it was very difficult to maintain high optical-character ability, the aberration fluctuation at the time of variable power or focusing having become large at this time, and attaining a miniaturization.
[0009] This invention attaining the miniaturization of the whole lens system while attaining formation of the diameter ratio of macrostomia, and high variable power-ization, adopting a rear focus method, it is crossed to the object distance at large [from an infinite distance body to / migrates to all the variable power range from a wide angle edge to a tele edge, and / a short-distance body], and aims at offer of the zoom lens of a rear focus type with a short lens overall length with good optical-character ability.

[0010]
[Means for Solving the Problem] The zoom lens of this invention in order [side / body] The 1st group of the forward refractive power of immobilization among variable power, It has four lens groups of the 2nd group of negative refractive power, the 3rd group of forward refractive power, and the 4th group of forward refractive power. Move this 2nd group to an image surface side, perform variable power from a wide angle edge to a tele edge, while moving this 4th group and amending the image surface fluctuation accompanying variable power, move this 4th group, and a focus is performed. It is 0.8 <=TD/fT<=1.05 when the focal distance of the whole system [in / for the distance from the 1st lens side by the side of the body when removing the optical member which does not have refractive power in an image surface side to the paraxial image surface / TD and a tele edge] is set to fT. ..... (1)
It is characterized by satisfying the becoming conditions.
[0011]
[Embodiment of the Invention] Drawing 1 is the lens sectional view of the wide angle edge of the numerical example 1 of this invention. The 3rd group of refractive power forward in the 1st group of refractive power forward in L1, the 2nd group of refractive power negative in L2, and L3 or negative and L4 are the 4th group of forward refractive power among drawing. SP extracts, IP is the image surface and G is glass blocks, such as a light filter.
[0012] While moving the 2nd group L2 to an image surface side like an arrow head on the occasion of the variable power from a wide angle edge to a tele edge, the 4th group was moved so that it might have a convex locus in a body side, and the image surface fluctuation accompanying variable power is amended.
[0013] Moreover, the rear focus type which is made to move the 4th group L4 on an optical axis, and performs a focus is adopted. Curvilinear 4a of the 4th group L4 shown in this drawing and curvilinear 4b show the migration locus at the time of following on the variable power from a wide angle edge when carrying out the focus to the infinite distance body and the short-distance body respectively to a tele edge. The 1st group L1 and the 3rd group L3 are immobilization in the case of variable power and a focus. In addition, in order to lessen the variable power assignment of the 2nd group, the 1st group may be moved in connection with variable power.
[0014] In this operation gestalt, when performing a focus from an infinite distance body to a short-distance body in a tele edge, it is carrying out by letting out the 4th group to the front, as shown in straight-line 4c of this drawing. With this operation gestalt, increase-ization of the lens effective diameter of the 1st group is effectively prevented by taking the above rear focus methods compared with the case where let out the 1st group in the conventional 4 group zoom lens, and a focus is performed.
[0015] And the distance TD from the 1st lens side by the side of the body when removing the optical member which does not have refractive power in an image surface side like the above-mentioned to the paraxial image surface Attaining the miniaturization of the whole lens system by specifying each element so that the focal distance fT of the whole system in a tele edge may satisfy conditional expression (1) like the above-mentioned, it migrated to all variable power range, the object distance at large was covered further, and the zoom lens of a high variable power ratio with good optical-character ability has been obtained.
[0016] If it is going to attain the miniaturization of a lens overall length exceeding the lower limit of conditional expression (1), the PETTSU bar sum will become large to a negative direction too much, and amendment of a curvature of field will become difficult. Conversely, if the upper limit of conditional expression (1) is exceeded, although it becomes easy, since the lens overall length is too long, aberration amendment is not good.
[0017] And in this invention, while constituting the 3rd group from one positive lens and one negative lens of the shape of a meniscus which turned the convex to the body side sequentially from a body side and considering the 3rd group as the so-called tele photograph type of lens configuration, in order to use effectively the tooth space formed among those lenses, aperture-diaphragm SP is stationed in the meantime, and, thereby, compaction of the lens overall length after the 3rd group is enabled.
[0018] Next, this is explained. In order to attain the miniaturization of a zoom lens, it is necessary to strengthen in the range without the problem of aberration amendment of the negative refractive power of the 2nd group, and to lessen movement magnitude for the variable power of the 2nd group. If negative refractive power of the 2nd group is strengthened, according to it, emission of the flux of light from the 2nd group will become strong. Therefore, it is effective to make small principal point spacing between the 2nd group and the 3rd group, for shortening the lens overall length after the 3rd group.
[0019] However, with the conventional zoom lens, the aperture diaphragm was arranged between the 2nd group and the 3rd group. The tooth space for arranging a diaphragm for this reason needed to be secured into the lens system. Since refractive power of the negative lens of the 3rd group needed to be strengthened so much and the looking-far ratio needed to be raised more when it was going to contract the lens overall length after the 3rd group by force at this time, the PETTSU bar sum of the whole system which became large by having

strengthened the refractive power of the 2nd group negative increased to the negative direction further, and there was an inclination for amendment of a sagittal curvature of field to become difficult especially.
[0020] on the other hand, arrange an aperture diaphragm between the positive lenses and negative lenses in the 3rd lens group, and spacing of the 2nd group and the 3rd group be shrunken by this invention -- by extending spacing of the positive lens and negative lens of the 3rd group conversely Increase of the negative PETTSU bar sum when making small distance from the 3rd group to the image surface is reduced, and this is amending the curvature of field at the time of compaction of a lens overall length good.
[0021] Although the zoom lens made into the purpose of this invention is attained by satisfying the above terms and conditions, in order to secure high optical-character ability over all variable power range, attaining the miniaturization of the whole lens system further, it is good to satisfy at least one of the following terms and conditions.
[0022] (b) When setting a focal distance [in / for air spacing of said 2nd group and 3rd group in a tele edge / D 2 and 3 and the wide angle edge of the whole system] to fW, it is 0.05<D2 and 3/fW<0.2. ..... (2)
It is satisfying the becoming conditions.
[0023] Conditional expression (2) is a thing for attaining shortening of a lens overall length effectively. Since the 2nd group and the 3rd group will contact when moving the 2nd group by adjustment etc. if this spacing 2 and D 3 becomes small exceeding the lower limit of conditional expression (2), it is not good. Moreover, since compaction of a lens overall length will become inadequate if a upper limit is exceeded conversely, it is not good.
(b) Said 1st group is nu1N<23, when it has at least one negative lens and the refractive index and the Abbe number of the quality of the material of this negative lens are respectively set to N1N and nu1N. ..... (3)
1.85<N1N ..... (4)
It is satisfying the becoming conditions.
[0024] Conditional expression (3) and (4) are the things for amending chromatic aberration good, making thickness of the lens group itself [each] thin, in order to shorten a lens overall length. While heightening the effectiveness of achromatism by using ** material which satisfies conditional expression (3) and (4) and making lens thickness of a positive lens thin, it has improved that the PETTSU bar sum of the whole system becomes a big value especially to a negative direction.
[0025] (c) It is [0026] when setting respectively the focal distance of the whole system [in / for the focal distance of said 2nd group / f2, a tele edge, and a wide angle edge] to fT and fW.
[Equation 2]

$$0.2 < |f2/\sqrt{fW \cdot fT}| < 0.3 \quad \cdots\cdots (5)$$

It is satisfying the becoming conditions.
[0027] Conditional expression (5) is a thing for shortening the lens length of the variable power section and attaining the further lens overall-length compaction.
[0028] It is a thing for obtaining a predetermined variable power ratio effectively, especially conditional expression (5) setting up the refractive power of the 2nd group appropriately, and lessening aberration fluctuation accompanying variable power. If the refractive power of the 2nd group becomes strong too much exceeding a lower limit, the miniaturization of the whole lens system will become easy, but the PETTSU bar sum increases to a negative direction, and while a curvature of field becomes large, the aberration fluctuation accompanying variable power becomes large. Moreover, if the refractive power of the 2nd group becomes weak too much exceeding a upper limit, the aberration fluctuation accompanying variable power will decrease, but since the movement magnitude of the 2nd group for obtaining a predetermined variable power ratio increases and a lens overall length becomes long, it is not good.
[0029] (d) It is using at least one aspheric surface into the 3rd group or/and the 4th group. It becomes easy to amend many aberration good, lessening lens number of sheets according to this.
[0030] Next, the numerical example of this invention is shown. a numerical example -- setting -- Ri -- a body side -- the i-th lens thickness and air spacing, nickel, and nui are the radius of curvatures of the i-th lens side, and Di is the refractive index and the Abbe number of glass of the i-th lens in order from an each body side in a body side. Moreover, the two last lens sides in a numerical example are glass blocks, such as a face plate and a filter. Moreover, the relation between the above-mentioned monograph affair type and many numeric values in a numerical example is shown in Table -1. An aspheric surface configuration is [0031], when the travelling direction of H shaft and light was made forward to the X-axis, the optical axis, and the perpendicular direction in the direction of an optical axis, R is made into paraxial radius of curvature and it makes K, B, C, D, and E an aspheric surface multiplier respectively.
[Equation 3]

$$X=\frac{(1/R)\,H^2}{1+\sqrt{1-(1+K)(H/R)^2}}+BH^4+CH^6+DH^8+EH^{10}$$

It expresses with the becoming formula. Moreover, the display of "e-0X" means "10-X."

[0032]

[External Character 1]

数値実施例 1

f =1～ 10.00　Fno= 1.84 ～ 2.64　2ω=61.6° ～ 6.8°

R 1 =	11.980	D 1 =	0.17	N 1 =	1.92286	ν 1 =	20.9
R 2 =	4.180	D 2 =	1.10	N 2 =	1.78589	ν 2 =	44.2
R 3 =	-19.421	D 3 =	0.04				
R 4 =	3.000	D 4 =	0.55	N 3 =	1.77249	ν 3 =	49.6
R 5 =	6.278	D 5 =	可変				
R 6 =	5.431	D 6 =	0.12	N 4 =	1.88299	ν 4 =	40.8
R 7 =	0.949	D 7 =	0.49				
R 8 =	-1.178	D 8 =	0.12	N 5 =	1.66671	ν 5 =	48.3
R 9 =	1.518	D 9 =	0.42	N 6 =	1.84665	ν 6 =	23.8
R10 =	-10.463	D10 =	可変				
R11 =	1.419	D11 =	0.61	N 7 =	1.58312	ν 7 =	59.4
R12 =	-4.395	D12 =	0.17				
R13 =	絞り	D13 =	0.19				
R14 =	1.638	D14 =	0.12	N 8 =	1.92286	ν 8 =	20.9
R15 =	1.107	D15 =	可変				
R16 =	1.961	D16 =	0.54	N 9 =	1.58312	ν 9 =	59.4
R17 =	-1.745	D17 =	0.12	N10 =	1.84665	ν10 =	23.8
R18 =	-3.575	D18 =	0.18				
R19 =	∞	D19 =	0.80	N11 =	1.51633	ν11 =	64.2
R20 =	∞						

＼焦点距離	1.00	5.04	10.00
可変間隔＼			
D 5	0.17	2.01	2.53
D10	2.45	0.62	0.10
D15	1.48	0.55	1.48

非球面係数

R11 k=-1.543　B=1.372 e-02 C=-1.849 e-03 D=9.079 e-03 E=-2.990 e-03

R12 k=-9.270　B=-1.172 e-03 C=7.837 e-03 D=0　E=0

R15 k=-4.313 e-02 B=-1.153 e-02 C=8.980 e-03 D=-3.936 e-03 E=-9.666 e-03

[0033]

[External Character 2]

数値実施例 2

f＝1～ 10.00　Fno＝ 1.84 ～ 2.65　2ω＝61.6°　～ 6.8°

R 1 =	11.777	D 1 =	0.17	N 1 =	1.92286	ν 1 =	20.9
R 2 =	4.095	D 2 =	1.10	N 2 =	1.78589	ν 2 =	44.2
R 3 =	-18.171	D 3 =	0.04				
R 4 =	2.902	D 4 =	0.55	N 3 =	1.77249	ν 3 =	49.6
R 5 =	5.902	D 5 =	可変				
R 6 =	5.507	D 6 =	0.12	N 4 =	1.88299	ν 4 =	40.8
R 7 =	0.928	D 7 =	0.48				
R 8 =	-1.147	D 8 =	0.12	N 5 =	1.66671	ν 5 =	48.3
R 9 =	1.478	D 9 =	0.42	N 6 =	1.84665	ν 6 =	23.8
R10 =	-10.230	D10 =	可変				
R11 =	1.414	D11 =	0.61	N 7 =	1.58312	ν 7 =	59.4
R12 =	-4.268	D12 =	0.17				
R13 =	絞り	D13 =	0.19				
R14 =	1.643	D14 =	0.12	N 8 =	1.92286	ν 8 =	20.9
R15 =	1.107	D15 =	可変				
R16 =	1.953	D16 =	0.54	N 9 =	1.58312	ν 9 =	59.4
R17 =	-1.737	D17 =	0.12	N10 =	1.84665	ν10 =	23.8
R18 =	-3.539	D18 =	0.18				
R19 =	∞	D19 =	0.80	N11 =	1.51633	ν11 =	64.2
R20 =	∞						

＼焦点距離	1.00	5.04	10.00
可変間隔＼			
D 5	0.17	1.95	2.46
D10	2.38	0.60	0.10
D15	1.49	0.55	1.49

非球面係数

R11 k=-1.563　B=1.324 e-02 C=-1.173 e-03 D=1.018 e-02 E=-3.512 e-03

R12 k=-8.513　B=-1.430 e-03 C=9.331 e-03 D=0　E=0

R16 k=3.755 e-02 B=-1.285 e-02 C=7.704 e-03 D=-5.117 e-03 E=-5.486 e-03

[0034]
[External Character 3]

数値実施例 3

f =1～ 10.00　Fno= 1.84 ～ 2.65　2ω=61.6°　～ 6.8°

R 1 =	12.441	D 1 =	0.17	N 1 = 1.923070	ν 1 = 18.9
R 2 =	4.130	D 2 =	1.09	N 2 = 1.806098	ν 2 = 41.0
R 3 =	-19.686	D 3 =	0.04		
R 4 =	2.971	D 4 =	0.55	N 3 = 1.785896	ν 3 = 44.2
R 5 =	6.043	D 5 =	可変		
R 6 =	5.183	D 6 =	0.12	N 4 = 1.882997	ν 4 = 40.8
R 7 =	0.938	D 7 =	0.49		
R 8 =	-1.163	D 8 =	0.12	N 5 = 1.666718	ν 5 = 48.3
R 9 =	1.499	D 9 =	0.42	N 6 = 1.846659	ν 6 = 23.8
R10 =	-11.019	D10 =	可変		
R11 =	1.418	D11 =	0.61	N 7 = 1.583126	ν 7 = 59.4
R12 =	-4.314	D12 =	0.17		
R13 =	絞り	D13 =	0.19		
R14 =	1.640	D14 =	0.12	N 8 = 1.922862	ν 8 = 20.9
R15 =	1.107	D15 =	可変		
R16 =	1.971	D16 =	0.54	N 9 = 1.583126	ν 9 = 59.4
R17 =	-1.734	D17 =	0.12	N10 = 1.846659	ν10 = 23.8
R18 =	-3.505	D18 =	0.18		
R19 =	∞	D19 =	0.80	N11 = 1.516330	ν11 = 64.2
R20 =	∞				

＼焦点距離	1.00	5.03	10.00
可変間隔＼			
D 5	0.17	1.98	2.49
D10	2.42	0.61	0.10
D15	1.49	0.56	1.49

非球面係数

R11 k=-1.548　B=1.291 e-02 C=-1.786 e-03 D=9.025 e-03 E=-3.035 e-03

R12 k=-8.772　B=-1.331 e-03 C=7.683 e-03 D=0　E=0

R16 k=-7.274 e-02 B=-9.730 e-03 C=4.884 e-03 D=-7.093 e-04 E=-7.646 e-03

[0035]
[Table 1]
表－1

条 件 式	数値実施例1	数値実施例2	数値実施例3
(1) TD／fT	1.03	1.03	1.04
(2) D2,3／fW	0.097	0.097	0.097
(3) ν_{1N}	20.9	20.9	18.9
(4) N_{1N}	1.9229	1.9229	1.9230
(4) f2／$\sqrt{fW \cdot fT}$	0.262	0.254	0.258

[0036]
[Effect of the Invention] Attaining the miniaturization of the whole lens system, while attaining formation of the diameter ratio of macrostomia, and high variable power-ization, adopting a rear focus method by setting up each element as mentioned above according to this invention, the object distance at large [from an infinite distance

body to / migrates to all the variable power range from a wide angle edge to a tele edge, and / a short-distance body] can be covered, and the zoom lens of a rear focus type with a short lens overall length with good optical-character ability can be attained.

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(71) Applicant: **CANON INC**

(72) Inventor: **HAMANO HIROYUKI**

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SOLUTION: This zoom lens is provided with the four lens groups of a first group L1 having positive refracting power which is fixed in the middle of variable power, a second group L2 having negative refracting power, a third group L3 having positive refracting power, and a fourth group L4 having positive refracting power in order from an object side; the variable power from a wide angle end to a telephoto end is performed by moving the second group L2 on an image surface side, image surface fluctuation in accordance with the variable power is corrected by moving the fourth group L4, and also focusing is performed by moving the fourth group L4. Assuming that a distance from a first lens surface on the object side to a paraxial image surface is defined as TD when an optical member without the refracting power on the image surface side is removed, and the focal distance of an entire system on the telephoto end is defined as fT, the condition of $0.8 \leqq TD/fT \leqq 1.05$ is satisfied.

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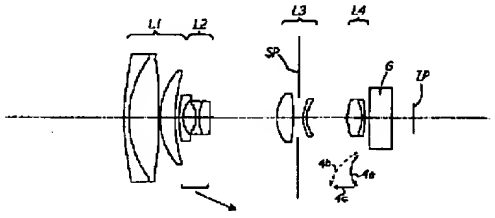

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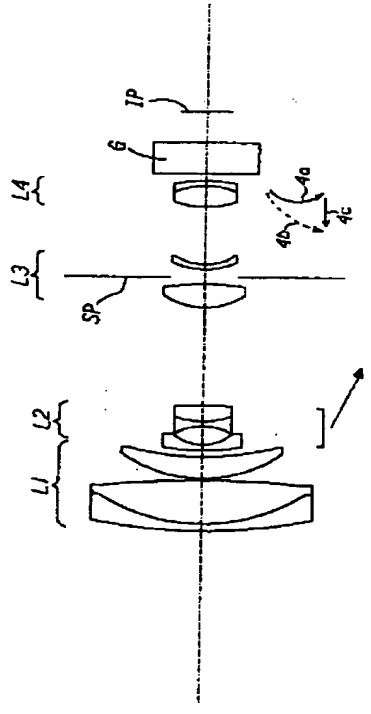
(54)【発明の名称】ズームレンズ

(57)【要約】

【課題】　レンズ系全体の小型化を図った４つのレンズ群より成るリヤーフォーカス式のズームレンズを得ること。

【解決手段】　物体側より順に変倍中固定の正の屈折力の第１群、負の屈折力の第２群、正の屈折力の第３群、そして正の屈折力の第４群の４つのレンズ群を有し、該第２群を像面側へ移動させて広角端から望遠端への変倍を行い、変倍に伴う像面変動を該第４群を移動させて補正すると共に該第４群を移動させてフォーカスを行い、像面側に屈折力を有しない光学部材を取り去ったときの物体側の第１レンズ面から近軸像面までの距離ＴＤ、望遠端における全系の焦点距離ｆＴを各々適切に設定したこと。



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【特許請求の範囲】

【請求項１】　物体側より順に変倍中固定の正の屈折力の第１群、負の屈折力の第２群、正の屈折力の第３群、そして正の屈折力の第４群の４つのレンズ群を有し、該第２群を像面側へ移動させて広角端から望遠端への変倍を行い、変倍に伴う像面変動を該第４群を移動させて補正すると共に該第４群を移動させてフォーカスを行い、像面側に屈折力を有しない光学部材を取り去ったときの物体側の第１レンズ面から近軸像面までの距離をＴＤ、望遠端における全系の焦点距離をｆＴとしたとき

０．８≦ＴＤ／ｆＴ≦１．０５

なる条件を満足することを特徴とするズームレンズ。

【請求項２】　望遠端における前記第２群と第３群の空気間隔をＤ２，３、全系の広角端における焦点距離をｆＷとするとき

０．０５＜Ｄ２，３／ｆＷ＜０．２

なる条件を満足することを特徴とする請求項１のズームレンズ。

【請求項３】　前記第３群は正レンズと物体側に凸面を向けたメニスカス状の負レンズより成っていることを特徴とする請求項１又は２のズームレンズ。

【請求項４】　前記第３群中の正レンズと負レンズとの間に絞りを有していることを特徴とする請求項３のズームレンズ。

【請求項５】　前記第１群は少なくとも１つの負レンズを有し、該負レンズの材質の屈折率とアッベ数を各々N_{1N}，ν_{1N}としたとき

ν_{1N}＜２３

１．８５＜N_{1N}

なる条件を満足することを特徴とする請求項１又は２のズームレンズ。

【請求項６】　前記第２群の焦点距離をｆ２、望遠端と広角端における全系の焦点距離を各々ｆＴ，ｆＷとするとき

【数１】

$$0.2 < |f2/\sqrt{fW \cdot fT}| < 0.3$$

なる条件を満足することを特徴とする請求項１又は２のズームレンズ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明はズームレンズに関し、特に写真用カメラやビデオカメラそして放送用カメラ等に用いられる変倍比１０、Ｆナンバー１．８～２．６程度で、広角端の撮影画角が６０度以上の大口径比で高変倍比のレンズ全長の短い小型のズームレンズに関するものである。

【０００２】

【従来の技術】従来より写真用カメラやビデオカメラ等のズームレンズにおいては物体側の第１群以外のレンズ

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群を移動させてフォーカスを行う、所謂リヤーフォーカス式を採用したものが種々と提案されている。

【０００３】一般にリヤーフォーカス式のズームレンズは第１群を移動させてフォーカスを行うズームレンズに比べて第１群の有効径が小さくなり、レンズ系全体の小型化が容易になり、また近接撮影、特に極近接撮影が容易となり、更に比較的小型軽量のレンズ群を移動させて行っているのでレンズ群の駆動力が小さくてすみ迅速な焦点合わせができるなどの特長がある。

【０００４】特開昭６２－２４７３１６号公報や特開昭６２－２４２１３号公報そして特開平５－６０９７４号公報では、物体側より順に正の屈折力の第１群、負の屈折力の第２群、正の屈折力の第３群、そして正の屈折力の第４群の４つのレンズ群を有し、第２群を移動させて変倍を行い、第４群を移動させて変倍に伴う像面変動とフォーカスを行っている。

【０００５】これらのうち、特開平５－６０９７４号公報では、第３群を正レンズと物体側に凸面を向けたメニスカス状の負レンズより構成してレンズ全長の短縮化を図っている。

【０００６】

【発明が解決しようとする課題】一般にズームレンズにおいてリヤーフォーカス方式を採用すると、レンズ系全体が小型化され、また迅速なるフォーカスが可能となる。しかしながら反面、フォーカスの際の収差変動が大きくなり、無限遠物体から近距離物体に至る物体距離全般にわたりレンズ系全体の小型化を図りつつ高い光学性能を得るのが大変難しくなってくるという問題点が生じてくる。特に大口径比で高変倍のズームレンズでは、全変倍範囲にわたり又物体距離全般にわたり高い光学性能を得るのが大変難しくなってくるという問題点が生じてくる。

【０００７】例えば、前述した４つのレンズ群より成るズームレンズにおいて第３群の屈折力を強めて第３群以降のレンズ全長を短縮しようとすると、第４群の変倍あるいはフォーカシング時の移動量が大きくなりすぎてズーム中間領域の近接物体に対して第３群と第４群がメカ的に干渉したり、第３群と第４群の空気間隔を広げなければならなくなってレンズ全長が逆に長くなってしまうという問題点があった。

【０００８】またこのとき変倍やフォーカシング時の収差変動が大きくなり、小型化を図りつつ高い光学性能を維持するのは大変困難であった。

【０００９】本発明はリヤーフォーカス方式を採用しつつ、大口径比化及び高変倍化を図ると共にレンズ系全体の小型化を図りつつ、広角端から望遠端に至る全変倍範囲にわたり、また無限遠物体から近距離物体に至る物体距離全般にわたり、良好なる光学性能を有したレンズ全長の短いリヤーフォーカス式のズームレンズの提供を目的とする。

【００１０】

【課題を解決するための手段】本発明のズームレンズは、物体側より順に変倍中固定の正の屈折力の第１群、負の屈折力の第２群、正の屈折力の第３群、そして正の屈折力の第４群の４つのレンズ群を有し、該第２群を像面側へ移動させて広角端から望遠端への変倍を行い、変倍に伴う像面変動を該第４群を移動させて補正すると共に該第４群を移動させてフォーカスを行い、像面側に屈折力を有しない光学部材を取り去ったときの物体側の第１レンズ面から近軸像面までの距離をＴＤ、望遠端における全系の焦点距離をｆＴとしたとき

０．８≦ＴＤ／ｆＴ≦１．０５　　……（１）

なる条件を満足することを特徴としている。

【００１１】

【発明の実施の形態】図１は本発明の数値実施例１の広角端のレンズ断面図である。図中、Ｌ１は正の屈折力の第１群、Ｌ２は負の屈折力の第２群、Ｌ３は正又は負の屈折力の第３群、Ｌ４は正の屈折力の第４群である。ＳＰは絞り、ＩＰは像面、Ｇは光学フィルター等のガラスブロックである。

【００１２】広角端から望遠端への変倍に際して矢印のように第２群Ｌ２を像面側へ移動させると共に、変倍に伴う像面変動を第４群を物体側に凸状の軌跡を有するように移動させて補正している。

【００１３】又、第４群Ｌ４を光軸上移動させてフォーカスを行うリヤーフォーカス式を採用している。同図に示す第４群Ｌ４の曲線４ａ，曲線４ｂは、各々無限遠物体，近距離物体に各々フォーカスしているときの広角端から望遠端への変倍に伴う際の移動軌跡を示している。第１群Ｌ１と第３群Ｌ３は変倍及びフォーカスの際、固定である。尚、第２群の変倍分担を少なくする為に変倍に伴い第１群を移動させても良い。

【００１４】本実施形態において、例えば望遠端において無限遠物体から近距離物体へフォーカスを行う場合は、同図の直線４ｃに示すように第４群を前方へ繰り出すことにより行っている。本実施形態では従来の４群ズームレンズにおいて第１群を繰り出してフォーカスを行う場合に比べて、前述のようなリヤーフォーカス方式を採ることにより第１群のレンズ有効径の増大化を効果的に防止している。

【００１５】そして前述の如く像面側に屈折力を有しない光学部材を取り去ったときの物体側の第１レンズ面から近軸像面までの距離ＴＤと、望遠端における全系の焦点距離ｆＴが前述の如く条件式（１）を満足するように各要素を特定することによってレンズ系全体の小型化を図りつつ、全変倍範囲にわたり、更に物体距離全般にわたり、良好なる光学性能を有した高変倍比のズームレンズを得ている。

【００１６】条件式（１）の下限値を越えてレンズ全長の小型化を図ろうとするとペッツバール和が負の方向に

大きくなりすぎて像面湾曲の補正が困難になる。逆に条件式（１）の上限値を越えると収差補正は容易になるがレンズ全長が長すぎるので良くない。

【００１７】そして本発明では第３群を物体側から順に１枚の正レンズと物体側に凸面を向けたメニスカス状の１枚の負レンズで構成し、第３群をいわゆるテレフォトタイプのレンズ構成とすると共に、それらのレンズ間に形成されるスペースを効果的に利用する為にその間に開口絞りＳＰを配置し、これにより第３群以降のレンズ全長の短縮を可能としている。

【００１８】次にこれについて説明する。ズームレンズの小型化を達成する為には、第２群の負の屈折力を収差補正の問題の無い範囲で強くして第２群の変倍の為の移動量を少なくする必要がある。第２群の負の屈折力を強くすると、それに応じて第２群からの光束の発散は強くなってくる。従って第３群以降のレンズ全長を短縮するには第２群と第３群の間の主点間隔を小さくすることが効果的である。

【００１９】ところが従来のズームレンズでは第２群と第３群の間に開口絞りを配置していた。この為絞りを配置する為のスペースをレンズ系中に確保する必要があった。このとき第３群以降のレンズ全長を無理に縮めようとすると、それだけ第３群の負レンズの屈折力を強くして、より望遠比を高める必要があった為、第２群の屈折力を強めたことで負に大きくなった全系のペッツバール和が更に負の方向に増大し、特にサジタルの像面湾曲の補正が困難になってくる傾向があった。

【００２０】これに対して本発明では開口絞りを第３レンズ群中の正レンズと負レンズの間に配置し、第２群と第３群との間隔を縮め、逆に第３群の正レンズと負レンズの間隔を広げることで、第３群から像面までの距離を小さくしたときの負のペッツバール和の増大を低減し、これによってレンズ全長の短縮時における像面湾曲の補正を良好に行っている。

【００２１】本発明の目的とするズームレンズは以上の諸条件を満足させることにより達成されるが、更にレンズ系全体の小型化を図りつつ全変倍範囲にわたり高い光学性能を確保する為には次の諸条件のうち少なくとも１つを満足させるのが良い。

【００２２】（イ）望遠端における前記第２群と第３群の空気間隔をＤ２，３、全系の広角端における焦点距離をｆＷとするとき

０．０５＜Ｄ２，３／ｆＷ＜０．２　　……（２）

なる条件を満足することである。

【００２３】条件式（２）はレンズ全長の短縮化を効果的に達成する為のものである。条件式（２）の下限値を越えてこの間隔Ｄ２，３が小さくなると第２群を調整等で移動させたときに第２群と第３群が接触してしまったりするので良くない。又逆に上限値を越えるとレンズ全長の短縮が不十分になってしまうので良くない。

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（ロ）前記第１群は少なくとも１つの負レンズを有し、該負レンズの材質の屈折率とアッベ数を各々N_{1N}，ν_{1N}としたとき

$\nu_{1N}<23$　　……（３）

$1.85<N_{1N}$　　……（４）

なる条件を満足することである。

【００２４】条件式（３），（４）はレンズ全長を短縮する為に各レンズ群自体の厚みを薄くしつつ、色収差を良好に補正する為のものである。条件式（３），（４）＊

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＊を満足するような硝材を使用することで色消しの効果を高め、正レンズのレンズ厚を薄くすると共に、全系のペッツバール和が特に負の方向に大きな値になってしまうのを改善している。

【００２５】（ハ）前記第２群の焦点距離をｆ２、望遠端と広角端における全系の焦点距離を各々ｆＴ，ｆＷとするとき

【００２６】

【数２】

$$0.2<|f2/\sqrt{fW\cdot fT}|<0.3 \qquad \cdots\cdots (5)$$

なる条件を満足することである。

【００２７】条件式（５）は変倍部のレンズ長を短縮して更なるレンズ全長短縮を達成する為のものである。

【００２８】特に条件式（５）は第２群の屈折力を適切に設定して変倍に伴う収差変動を少なくしつつ所定の変倍比を効果的に得る為のものである。下限値を越えて第２群の屈折力が強くなりすぎるとレンズ系全体の小型化は容易となるが、ペッツバール和が負の方向に増大し、像面湾曲が大きくなると共に変倍に伴う収差変動が大きくなる。又上限値を越えて第２群の屈折力が弱くなりすぎると変倍に伴う収差変動は少なくなるが、所定の変倍比を得る為の第２群の移動量が増大し、レンズ全長が長くなってくるので良くない。

【００２９】（ニ）第３群又は／及び第４群中に少なくとも１つの非球面を用いることである。これによればレ※

※ンズ枚数を少なくしつつ諸収差を良好に補正することが容易となる。

【００３０】次に本発明の数値実施例を示す。数値実施例においてＲｉは物体側より順に第ｉ番目のレンズ面の曲率半径、Ｄｉは物体側より第ｉ番目のレンズ厚及び空気間隔、Ｎｉとνｉは各々物体側より順に第ｉ番目のレンズのガラスの屈折率とアッベ数である。又、数値実施例において最終の２つのレンズ面はフェースプレートやフィルター等のガラスブロックである。又、前述の各条件式と数値実施例における諸数値との関係を表－１に示す。非球面形状は光軸方向にＸ軸、光軸と垂直方向にＨ軸、光の進行方向を正としＲを近軸曲率半径、Ｋ，Ｂ，Ｃ，Ｄ，Ｅを各々非球面係数としたとき、

【００３１】

【数３】

$$X=\frac{(1/R)H^2}{1+\sqrt{1-(1+K)(H/R)^2}}+BH^4+CH^6+DH^8+EH^{10}$$

なる式で表わしている。又「e-0X」の表示は「10^{-x}」を意味している。

【００３２】

【外１】

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数値実施例１

f＝1～10.00 Fno＝1.84～2.64 2ω＝61.6°～6.8°

R 1 =	11.980	D 1 =	0.17	N 1 = 1.92286	ν 1 = 20.9
R 2 =	4.180	D 2 =	1.10	N 2 = 1.78589	ν 2 = 44.2
R 3 =	-19.421	D 3 =	0.04		
R 4 =	3.000	D 4 =	0.55	N 3 = 1.77249	ν 3 = 49.6
R 5 =	6.278	D 5 =	可変		
R 6 =	5.431	D 6 =	0.12	N 4 = 1.88299	ν 4 = 40.8
R 7 =	0.949	D 7 =	0.49		
R 8 =	-1.178	D 8 =	0.12	N 5 = 1.66671	ν 5 = 48.3
R 9 =	1.518	D 9 =	0.42	N 6 = 1.84665	ν 6 = 23.8
R10 =	-10.463	D10 =	可変		
R11 =	1.419	D11 =	0.61	N 7 = 1.58312	ν 7 = 59.4
R12 =	-4.395	D12 =	0.17		
R13 =	絞り	D13 =	0.19		
R14 =	1.638	D14 =	0.12	N 8 = 1.92286	ν 8 = 20.9
R15 =	1.107	D15 =	可変		
R16 =	1.961	D16 =	0.54	N 9 = 1.58312	ν 9 = 59.4
R17 =	-1.745	D17 =	0.12	N10 = 1.84665	ν10 = 23.8
R18 =	-3.575	D18 =	0.18		
R19 =	∞	D19 =	0.80	N11 = 1.51633	ν11 = 64.2
R20 =	∞				

焦点距離 / 可変間隔	1.00	5.04	10.00
D 5	0.17	2.01	2.53
D10	2.45	0.62	0.10
D15	1.48	0.55	1.48

非球面係数

R11 k=-1.543 B=1.372 e-02 C=-1.849 e-03 D=9.079 e-03 E=-2.990 e-03

R12 k=-9.270 B=-1.172 e-03 C=7.837 e-03 D=0 E=0

R16 k=-4.313 e-02 B=-1.153 e-02 C=8.980 e-03 D=-3.936 e-03 E=-9.666 e-03

【００３３】 【外２】

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数値実施例 2

f＝1～ 10.00　Fno＝ 1.84 ～ 2.65　2ω＝61.6°　～ 6.8°

R 1 =	11.777	D 1 =	0.17	N 1 = 1.92286	ν 1 = 20.9
R 2 =	4.095	D 2 =	1.10	N 2 = 1.78589	ν 2 = 44.2
R 3 =	-18.171	D 3 =	0.04		
R 4 =	2.902	D 4 =	0.55	N 3 = 1.77249	ν 3 = 49.6
R 5 =	5.902	D 5 =	可変		
R 6 =	5.507	D 6 =	0.12	N 4 = 1.88299	ν 4 = 40.8
R 7 =	0.928	D 7 =	0.48		
R 8 =	-1.147	D 8 =	0.12	N 5 = 1.66671	ν 5 = 48.3
R 9 =	1.478	D 9 =	0.42	N 6 = 1.84665	ν 6 = 23.8
R10 =	-10.230	D10 =	可変		
R11 =	1.414	D11 =	0.61	N 7 = 1.58312	ν 7 = 59.4
R12 =	-4.288	D12 =	0.17		
R13 =	絞り	D13 =	0.19		
R14 =	1.643	D14 =	0.12	N 8 = 1.92286	ν 8 = 20.9
R15 =	1.107	D15 =	可変		
R16 =	1.953	D16 =	0.54	N 9 = 1.58312	ν 9 = 59.4
R17 =	-1.737	D17 =	0.12	N10 = 1.84665	ν10 = 23.8
R18 =	-3.539	D18 =	0.18		
R19 =	∞	D19 =	0.80	N11 = 1.51633	ν11 = 64.2
R20 =	∞				

焦点距離 / 可変間隔	1.00	5.04	10.00
D 5	0.17	1.95	2.46
D10	2.38	0.60	0.10
D15	1.49	0.55	1.49

非球面係数

R11 k=-1.563　B=1.324 e-02 C=-1.173 e-03 D=1.018 e-02 E=-3.512 e-03

R12 k=-8.513　B=-1.430 e-03 C=9.331 e-03 D=0　E=0

R16 k=3.755 e-02 B=-1.285 e-02 C=7.704 e-03 D=-5.117 e-03 E=-5.486 e-03

【００３４】　【外３】

数値実施例 3

f＝1～ 10.00　Fno＝ 1.84 ～ 2.65　2ω=61.6° ～ 6.8°

R 1 =	12.441	D 1 =	0.17	N 1 = 1.923070	ν 1 = 18.9
R 2 =	4.130	D 2 =	1.09	N 2 = 1.806098	ν 2 = 41.0
R 3 =	-19.686	D 3 =	0.04		
R 4 =	2.971	D 4 =	0.55	N 3 = 1.785896	ν 3 = 44.2
R 5 =	6.043	D 5 =	可変		
R 6 =	5.183	D 6 =	0.12	N 4 = 1.882997	ν 4 = 40.8
R 7 =	0.938	D 7 =	0.49		
R 8 =	-1.163	D 8 =	0.12	N 5 = 1.666718	ν 5 = 48.3
R 9 =	1.499	D 9 =	0.42	N 6 = 1.846659	ν 6 = 23.8
R10 =	-11.019	D10 =	可変		
R11 =	1.418	D11 =	0.61	N 7 = 1.583126	ν 7 = 59.4
R12 =	-4.314	D12 =	0.17		
R13 =	絞り	D13 =	0.19		
R14 =	1.640	D14 =	0.12	N 8 = 1.922862	ν 8 = 20.9
R15 =	1.107	D15 =	可変		
R16 =	1.971	D16 =	0.54	N 9 = 1.583126	ν 9 = 59.4
R17 =	-1.734	D17 =	0.12	N10 = 1.846659	ν10 = 23.8
R18 =	-3.505	D18 =	0.18		
R19 =	∞	D19 =	0.80	N11 = 1.516330	ν11 = 64.2
R20 =	∞				

焦点距離 / 可変間隔	1.00	5.03	10.00
D 5	0.17	1.98	2.49
D10	2.42	0.61	0.10
D15	1.49	0.56	1.49

非球面係数

R11 k=-1.548　B=1.291 e-02 C=-1.786 e-03 D=9.025 e-03 E=-3.035 e-03

R12 k=-8.772　B=-1.331 e-03 C=7.683 e-03 D=0　E=0

R16 k=-7.274 e-02 B=-9.730 e-03 C=4.884 e-03 D=-7.093 e-04 E=-7.646 e-03

【００３５】

＊　＊【表１】

表－１

条　件　式	数値実施例１	数値実施例２	数値実施例３
(1) TD／fT	1.03	1.03	1.04
(2) D2,3／fW	0.097	0.097	0.097
(3) ν_{1N}	20.9	20.9	18.9
(4) N_{1N}	1.9229	1.9229	1.9230
(4) f2／$\sqrt{fW \cdot fT}$	0.262	0.254	0.258

【００３６】

【発明の効果】本発明によれば以上のように各要素を設定することによりリヤーフォーカス方式を採用しつつ、大口径比化及び高変倍化を図ると共にレンズ系全体の小型化を図りつつ、広角端から望遠端に至る全変倍範囲にわたり、また無限遠物体から近距離物体に至る物体距離

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全般にわたり、良好なる光学性能を有したレンズ全長の短いリヤーフォーカス式のズームレンズを達成することができる。

【図面の簡単な説明】

【図１】本発明の数値実施例１の広角端のレンズ断面図

【図２】本発明の数値実施例１の広角端の収差図

【図３】本発明の数値実施例１の中間の収差図

【図４】本発明の数値実施例１の望遠端の収差図

【図５】本発明の数値実施例２の広角端の収差図

【図６】本発明の数値実施例２の中間の収差図

【図７】本発明の数値実施例２の望遠端の収差図

【図８】本発明の数値実施例３の広角端の収差図

【図９】本発明の数値実施例３の中間の収差図

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【図１０】本発明の数値実施例３の望遠端の収差図

【符号の説明】

Ｌ１　第１群

Ｌ２　第２群

Ｌ３　第３群

Ｌ４　第４群

ＳＰ　絞り

ｄ　ｄ線

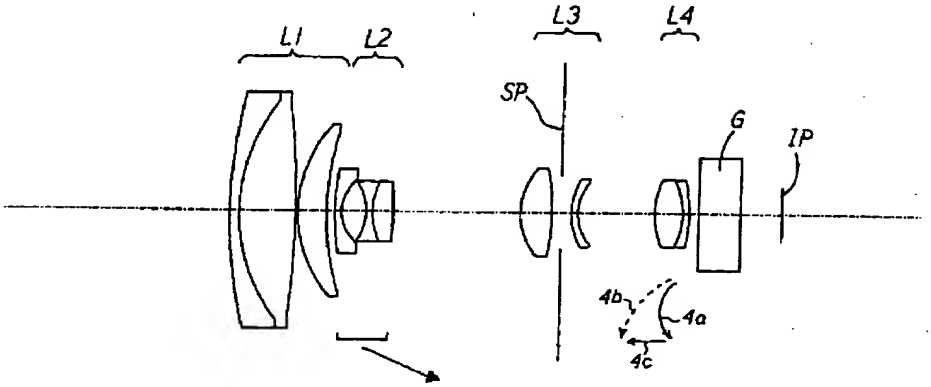
ｇ　ｇ線

ΔＳ　サジタル像面

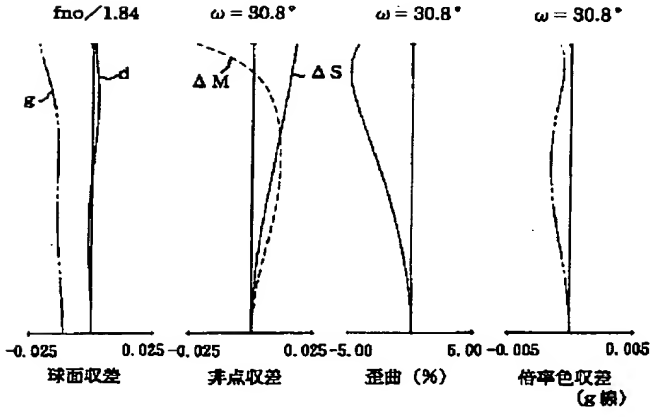
ΔＭ　メリディオナル像面

ＩＰ　像面

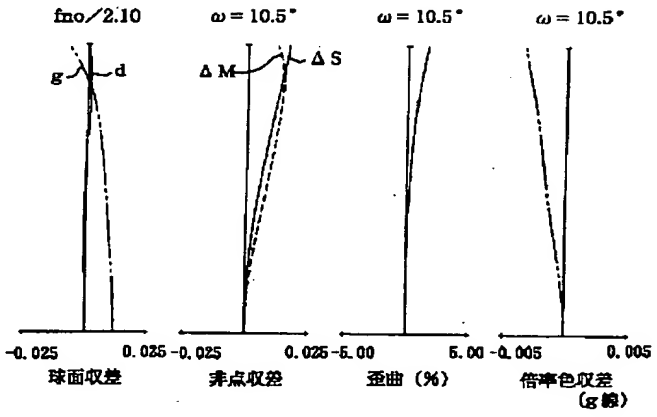
【図１】



【図２】



【図３】



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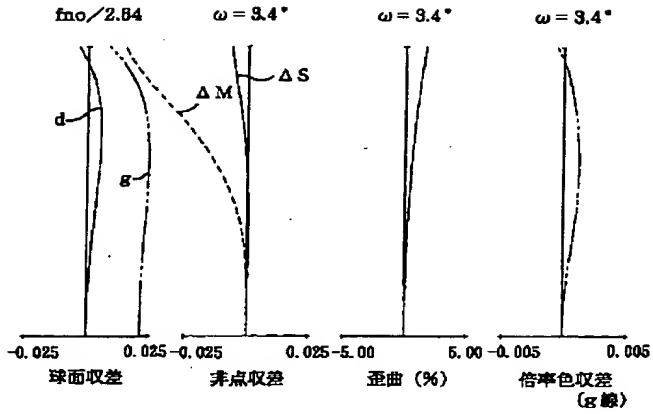
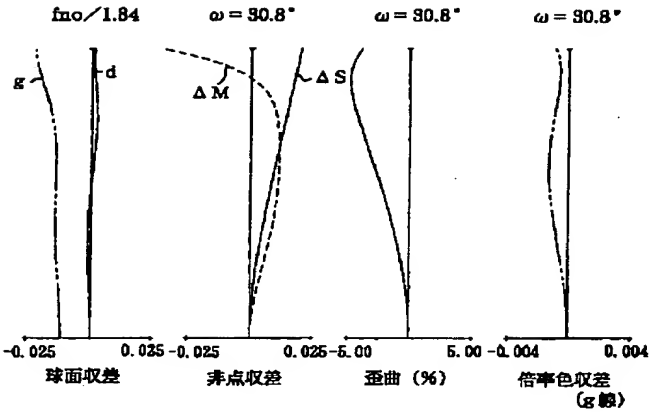
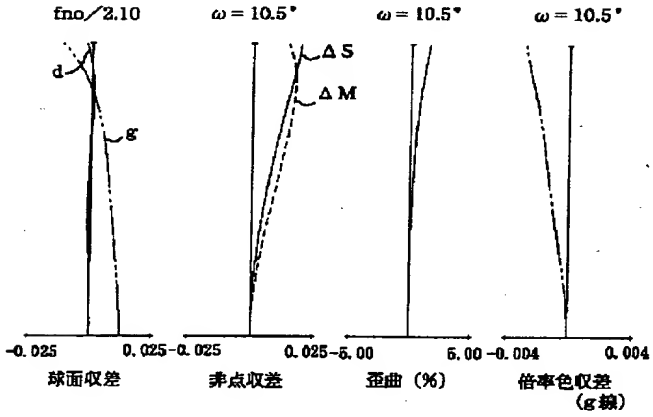


【図５】



【図６】



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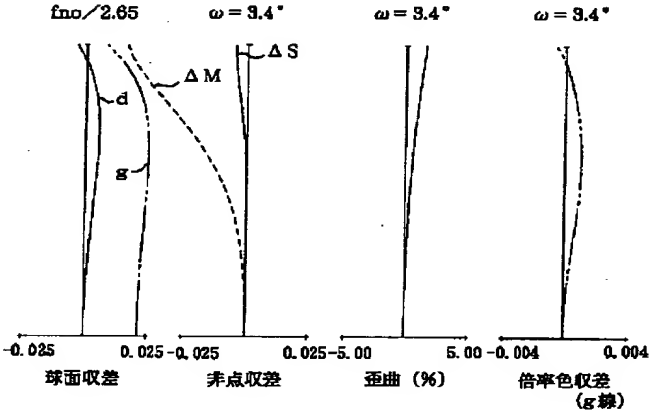
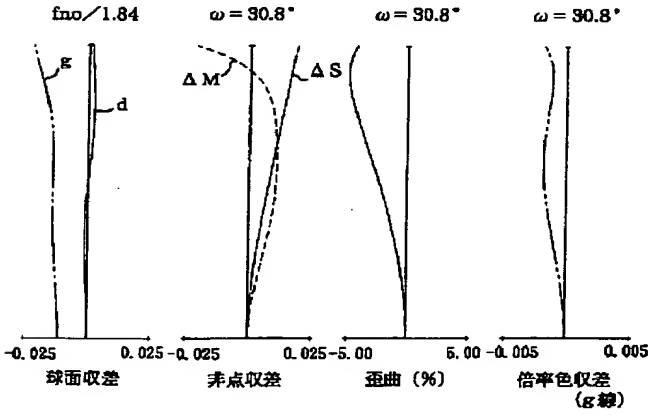
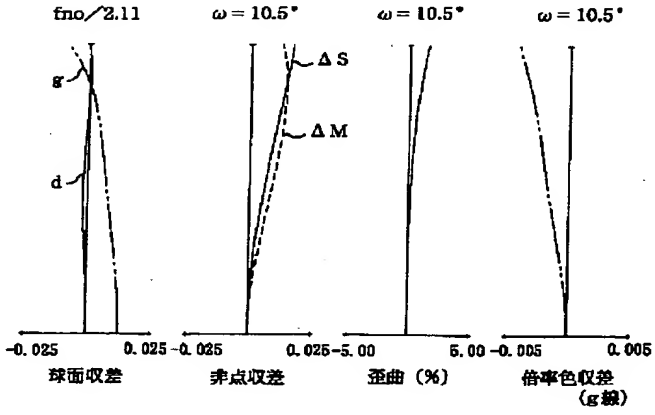


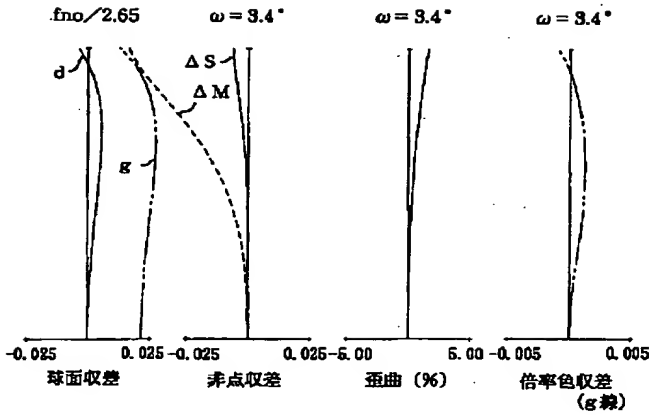
【図８】



【図９】



【図１０】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ω＝3.4°
ω＝3.4°
d
g
ΔS
ΔM
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0.025
-0.025
0.025
-5.00
5.00
-0.005
0.005
球面収差
非点収差
歪曲（%）
倍率色収差
（g線）